Can planet/sun conjunctions be used to predict large earthquake (>=Mw7) occurence?

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Abstract

No.

Introduction

Following the recent Mw 7.8 Kahramanmaraş, Türkiye earthquake sequence on 6 February 2023, the assertion that planet/sun alignments and lunar phases may help to predict earthquake became widespread in some bad quality news and social medias. In the following, we will call this alignment of three celestial body a conjunction, although the correct word must be a syzygy.

Usually, this assertion is promoted by choosing carefully period of time over which it occurs and showing specific earthquakes at which it occurs. Also they usually do not mention that these events do happen extremely frequently, and that most of the time, these alignments are not followed by significant earthquakes.

The only literature available about it put into question fundamental physics without any proof (Omerbashich, 2011; Safronov 2022), or does not show the background rate of conjunctions (Awadh, 2021).

The major logical flaw in their analysis is showing only events that are working while not paying attention to the total quantity of conjunctions (see Khalisi, 2021, Zanette 2011). Indeed, if conjunctions are very common, it is easy to associate them with earthquakes.

In this paper, we are testing the planet/sun alignment, together with the moon phase systematically over a 69 years period of time using global catalog of earthquakes. We are systematically comparing the percentage of earthquakes linked with conjunction(s) with the percentage of the time that conjunction(s) are happening. This assertion that planet/sun alignment is promoting earthquakes would be valid only if it is happening more frequently than conjunctions themselves.

This assertion can be seen as a more evolved version of that the moon phase is changing the earthquake. The moon phase theory, has been debated for a long time by seismologists (Schuster, 1897), and the question is still not completely answered yet (Ide et al., 2016; Hough, 2018; Kossobokov and Panza 2020; Zaccagnino et al., 2022). In some regions, slow-earthquakes like tremors (Nakata et al 2008, Rubinstein et al., 2008), or low frequency earthquake (Thomas et al., 2012) are influenced by tides. Depending on the area, the time in the seismic cycle (Tanaka 2010, 2012; Peng et al., 2021) and the focal mechanism of the earthquakes (Tsuruoka et al., 1995), it may have some influence or not. Overall, it seems to have an influence (Yan et al,. 2023), at least for some regions/period or time, that may be incorporated in long term probabilistic earthquake forecasting (Ide et al., 2016). Rigorous attempt to perform short term prediction with

the idea that before a large earthquake, smaller earthquakes would be more tide-sensitive as the crust is approaching critical strength, was proven to be ineffective (Hirose et al., 2022).

While for the moon/earth/sun alignements, there exists a physical mechanism by which the stresses are changing in the crust (the gravity), and therefore may weakly influence earthquake occurence (Ide et al., 2016), there is no such mechanism for planets/sun alignements, because the electromagnetic and gravity fields by celestial body other than sun and moon are usually extremely small when they reach the Earth. Therefore, invoking “electrodynamic”, “resonance”, and “molecule” as if they were keywords to explain the phenomena leading to this assertion only reflects the lack of scientific knowledge of the persons promoting this theory.

Method

We first chose the ISC-GEM catalog (Storchak et al., 2013; 2015; Di Giacomo et al., 2018) and selected earthquakes of Mw>7 over the period 1950/01/01-2018/12/31. The reason of selecting the year 1950, is because the catalog starts to be complete for shallow events (>60km) and for Mw>=7 at years 1918–1939 (Michael, 2014). We chose the 10 years delay as a margin to be sure not to miss Mw 7 earthquakes which may flaw the analysis.

To calculate each planet/sun alignment, we took advantage of the Astropy package in python (The astropy collaboration et al., 2018, 2022), that allows to calculate the position of any planets in the solar system, the sun, and the moon at any time. For each day covering the period of the earthquake catalog, we calculated if there was a conjunction or not. We used the NASA JPL ephemeris model “DE430”. We did not take into account leap seconds in the calculation of the day, because the offset is less than a minute for the considered period.

The celestial body included are: the Sun, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

For each triplet of given three celestial bodies A, B and C in the solar system, we calculated their positions in International Celestial Reference System (ICRS).

We then calculated each vector $\overrightarrow{AB}$, $\overrightarrow{BC}$ and $\overrightarrow{AC}$ and the associated norms $||\overrightarrow{AB}||$, $||\overrightarrow{BC}||$ and $||\overrightarrow{AC}||$. The vector that has the longest norm shows the two bodies whose distance is the greatest, hence we can find the body that is in the middle. For example, if $||\overrightarrow{AC}||$ is the greatest distance, we can guess that the celestial body B is in the middle. Finally, we can calculate the angle between $\overrightarrow{AB}$ and $\overrightarrow{BC}$ as:

$$\theta = \frac{180}{\pi} \arccos\left(\frac{\overrightarrow{AB}\cdot\overrightarrow{BC}}{|\overrightarrow{AB}||\overrightarrow{BC}|}\right) \text{ in degree}$$

When the angle θ was smaller than a threshold θ_{thr} we set that there was an alignment of the celestial bodies for the day.

For the moon phase, we calculated the projection of the moon on the ecliptic plan (the plan that contains the orbital of the Earth). Then, we try to find if the projection on this plan was in opposition (full Moon) or in conjunction (new Moon) with the sun from the Earth. A threshold of 6.5 degree was used, this threshold is chosen because the average orbital of the moon around the Earth during one day is around 12°.

Results

Number of days associated with conjunction(s)	Number of earthquakes associated with conjunction(s)	Number of earthquakes associated with full/new moon	Number of earthquakes associated with full/new moon	Number of days associated with both full/new moon and conjunction(s)	Number of earthquakes associated with both full/new moon and conjunction(s)
19565/25202 (77.63%)	640/813 (78.72%)	1743/25202 (6.92%)	58/813 (7.13%)	1349/25202 (5.35%)	52/813 (6.40%)

Table 1: comparison of the frequency of a particular event (for example a conjunction), and the frequency of an earthquake that can be associated to the event during the period 1950/01/01-2018/12/31. The threshold used here to define a conjunction is $\theta_{thr} = 3°$.

The results are presented in the above chart (table 1). The total period consists of 25202 days, among which 19565 days are associated with conjunctions. So that 78% of the time, there is at least one conjunction on the day. For the same period, there are 813 earthquakes, among which 640 are associated with conjunctions, so that 79% percent of earthquakes are associated with conjunctions.

We did the same study for earthquakes associated with full or new moon, as well as for earthquakes associated with both full or new moon, and at least one conjunction. The percentage of days associated with either full or new moon is 7% (1743/25202), very much the same as the number of earthquakes that happened during full or new moon 7% (58/813). Finally, there are 5% (1349/25202) of days, and 6% (52/813) of earthquakes associated with both full or new moon, and at least one conjunction.

Discussion and Conclusion

The frequency of earthquake associated with conjunction and the frequency of conjunctions are pretty much the same, and the difference is probably statistically irrelevant (statistical test would be needed to decipher). This means that the association of earthquakes with conjunctions, is nothing more than sampling the number of times conjunctions are happening.

Nether-the-less, even in the case it would be relevant, this would be an extremely small effect that by no means should be used for short term earthquake prediction.

We also tried to find if a planet was more often that others associated with conjunctions (figure 1). It seems not the case because the difference between the percentage of planet/sun involved at least in one conjunction during one day is within 3% the same as the percentage of earthquakes that can be at least associated with a given planet/sun in a conjunction.

Finally, we tried to see if a conjunction was more often than others associated with earthquake occurence (figure 2). The results are less clear, because for a given conjunction, the percentage of this conjunction during the whole period is small (<2% for the conjunction that is the most frequent), so that the number of earthquakes sampling this conjunction is also very small. This

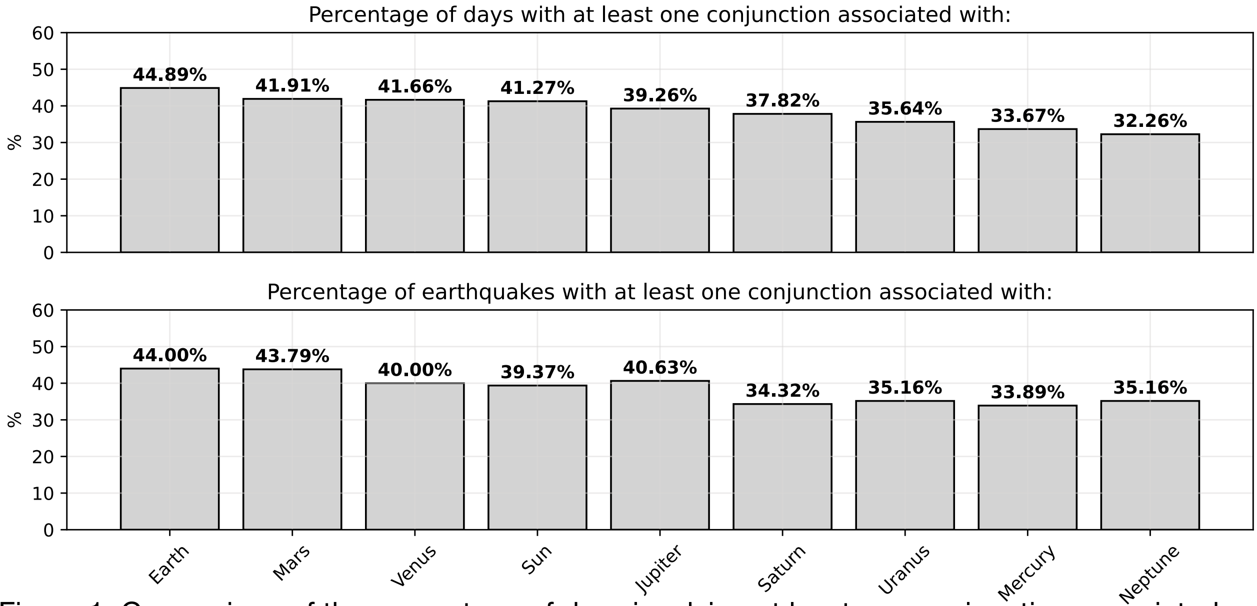

Figure 1: Comparison of the percentage of days involving at least one conjunction associated with a given planet, and the percentage of earthquakes linked with at least one conjunction associated with a given planet. The threshold angle to define a conjunction is $\theta_{thr} = 3^{\circ}$.

leads to a large variability. However, we can still say that the overall trend is respected, the conjunctions that are the most frequent are most often associated with earthquakes.

The change of the threshold for conjunction does not change the results, and the same conclusion can be made. If the threshold angle is too small, we may miss some conjunctions because the orbital plan is not exactly the same for each planet. For example, the results with the threshold of 2% is given in appendix (table 2). Reducing the threshold angle mainly reduces the percentage of time conjunctions are happening and reduces in the same way the percentage of earthquakes that are associated with conjunctions.

Persons defending the assertion of planetary/sun conjunctions may continue arguing that I still did not look at a particular association of conjunctions, or association with only full moon. This is true. But given the number of possible associations, it is impossible to test them all. If so, they are very welcomed to indicate these specific associations, so that it can be tested rigorously and scientifically, keeping in mind that normally the person making assertions should be the one proving them.

The alignment of three planets/sun are actually something extremely ordinary in the solar system that is happening close to everyday (for the threshold 3°, it happens 78% of the time). Finding a syzygy on the day of an earthquake is therefore normal, moreover if we start looking at some days before and after an earthquake. We showed that the percentage of earthquake associated with at least a conjunction is actually very similar to the percentage of the time where there is at least a conjunction. Hence, there is no significant effect of planet/sun alignment or moon effect on the occurence of large earthquakes, and it can certainly not be used to provide short term prediction. Finally to plagiarize Khalisi, 2021, “Sooner or later there will be another earthquake close to a ***conjunction***, and the self-proclaimed prophets will have their joy.”

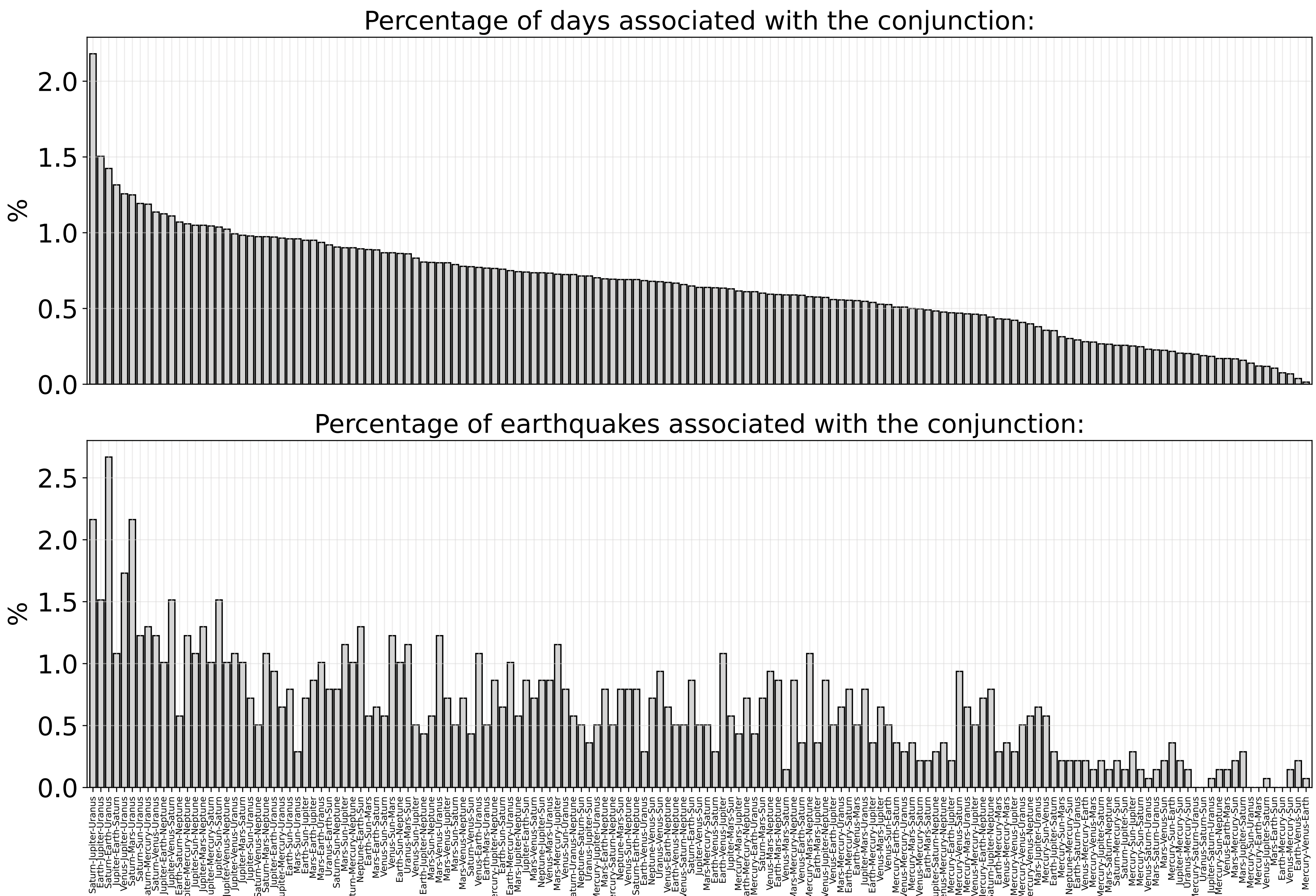

Figure 2: Comparison of the percentage of days that a specific conjunction happen, with the percentage of earthquakes that can be linked with the same specific conjunction. The threshold angle to define a conjunction is $\theta_{thr} = 3^{\circ}$.

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Data

International Seismological Centre (2018), ISC-GEM Earthquake Catalogue, https://doi.org/10.31905/d808b825

References

Awadh, S. M. (2021), Solar system planetary alignment triggers tides and earthquakes, Journal of Coastal Conservation, 25 (2), 30,
doi:10.1007/s11852-021-00822-7.

Di Giacomo, D., E. R. Engdahl, and D. A. Storchak (2018), The isc-gem earthquake catalogue (1904–2014): status after the extension project, Earth System Science Data, 10(4), 1877–1899,
doi:10.5194/essd-10-1877-2018.

Hirose, F., K. Maeda, and O. Kamigaichi (2022), Efficiency of earthquake forecast models based on earth tidal correlation with background seismicity along the Tonga–Kermadec trench, Earth, Planets and Space, 74 (1), 1–11,
doi:10.1186/s40623-021-01564-4.

Hough, S. E. (2018), Do large (magnitude≥8) global earthquakes occur on preferred days of the calendar year or lunar cycle?, Seismol. Res. Lett., 89(2A), 577–581,
doi: 10.1785/0220170154.

Ide, S. (2016), Characteristics of slow earthquakes in the very low frequency band: Ap- plication to the cascadia subduction zone, J. Geophys. Res., 121(8), 5942–5952,
doi: 10.1002/2016JB013085.

Khalisi, E. (2021), On the erroneous correlation between earthquakes and eclipses, arXiv preprint arXiv:2101.08572,
doi:10.48550/arXiv.2101.08572.

Kossobokov, V. G., and G. F. Panza (2020), A myth of preferred days of strong earth- quakes?, Seismol. Res. Lett., 91 (2A), 948–955,
doi:10.1785/0220190157.

Michael, A. J. (2014), How complete is the isc-gem global earthquake catalog?, Bull. Seism. Soc. Am., 104(4), 1829–1837,
doi:10.1785/0120130227.

Nakata, R., N. Suda, and H. Tsuruoka (2008), Non-volcanic tremor resulting from the combined effect of earth tides and slow slip events, Nature Geoscience, 1(10), 676–678,
doi:10.1038/ngeo288.

Omerbashich, M. (2011), Astronomical alignments as the cause of m6+ seismicity, arXiv preprint arXiv:1104.2036,
doi:10.48550/arXiv.1104.2036.

Peng, G., X. Lei, G. Wang, and F. Jiang (2021), Precursory tidal triggering and b value variation before the 2011 mw 5.1 and 5.0 tengchong, china earthquakes, Earth Planet. Sc. Lett., 574, 117,167,
doi:10.1016/j.epsl.2021.117167.

Price-Whelan, A. M., B. Sipo˝cz, H. Gu¨nther, P. Lim, S. Crawford, S. Conseil, D. Shupe, M. Craig, N. Dencheva, A. Ginsburg, et al. (2018), The astropy project: building an open-science project and status of the v2. 0 core package, The Astronomical Journal, 156(3), 123,
doi:10.3847/1538-3881/aabc4f.

Price-Whelan, A. M., P. L. Lim, N. Earl, N. Starkman, L. Bradley, D. L. Shupe, A. A. Patil, L. Corrales, C. Brasseur, M. No¨the, et al. (2022), The astropy project: sustaining and growing a community-oriented open-source project and the latest major release (v5. 0) of the core package, The Astrophysical Journal, 935(2), 167,
doi:10.3847/1538- 4357/ac7c74.

Rubinstein, J. L., M. La Rocca, J. E. Vidale, K. C. Creager, and A. G. Wech (2008), Tidal modulation of nonvolcanic tremor, Science, 319(5860), 186–189,
doi: 10.1126/science.1150558.

Safronov, A. N. (2022), Astronomical triggers as a cause of strong earthquakes, Interna- tional Journal of Geosciences, 13 (9), 793–829,
doi:10.4236/ijg.2022.139040.

Schuster, A. (1897), On lunar and solar periodicities of earthquakes, Proceedings of the Royal Society of London, 61(369-377), 455–465.

Storchak, D. A., D. Di Giacomo, I. Bondar, E. R. Engdahl, J. Harris, W. H. Lee, A. Villasenor, and P. Bormann (2013), Public release of the isc–gem global instrumental earth- quake catalogue (1900–2009), Seismol. Res. Lett., 84 (5), 810–815.

Storchak, D. A., D. Di Giacomo, E. Engdahl, J. Harris, I. Bonda´r, W. H. Lee, P. Bormann, and A. Villasenor (2015), The isc-gem global instrumental earthquake catalogue (1900– 2009): introduction, Physics of the Earth and Planetary Interiors, 239, 48–63,
doi: 10.1016/j.pepi.2014.06.009.

Tanaka, S. (2010), Tidal triggering of earthquakes precursory to the recent sumatra megathrust earthquakes of 26 december 2004 (mw 9.0), 28 march 2005 (mw 8.6), and 12 september 2007 (mw 8.5), Geophys. Res. Lett., 37(2),
doi:10.1029/2009GL041581.

Tanaka, S. (2012), Tidal triggering of earthquakes prior to the 2011 tohoku-oki earthquake (mw 9.1), Geophys. Res. Lett., 39 (7),
doi:10.1029/2012GL051179.

Thomas, A., R. Burgmann, D. R. Shelly, N. M. Beeler, and M. Rudolph (2012), Tidal triggering of low frequency earthquakes near parkfield, california: Implications for fault mechanics within the brittle-ductile transition, J. Geophys. Res., 117(B5),
doi: 10.1029/2011JB009036.

Tsuruoka, H., M. Ohtake, and H. Sato (1995), Statistical test of the tidal triggering of earthquakes: contribution of the ocean tide loading effect, Geophys. J. Int., 122(1), 183–194.

Yan, R., X. Chen, H. Sun, J. Xu, and J. Zhou (2023), A review of tidal triggering of global earthquakes, Geodesy and Geodynamics, 14(1), 35–42, doi:10.1016/j.geog.2022.06.005, contemporary research in Geodynamics and Earth Tides.

Zaccagnino, D., L. Telesca, and C. Doglioni (2022), Correlation between seismic activity and tidal stress perturbations highlights growing instability within the brittle crust, Scientific Reports, 12(1), 7109,
doi:10.1038/s41598-022-11328-z.

Zanette, D. H. (2011), Comment on ”astronomical alignments as the cause of m6+ seismicity”, arXiv preprint arXiv:1109.1240,
doi:10.48550/arXiv.1109.1240.

Appendix

Number of days associated with conjunction(s)	**Number of earthquakes associated with conjunction(s)**	**Number of earthquakes associated with full/new moon**	**Number of earthquakes associated with full/new moon**	**Number of days associated with both full/new moon and conjunction(s)**	**Number of earthquakes associated with both full/new moon and conjunction(s)**
13908/25202 (55.19%)	463/813 (56.95%)	1743/25202 (6.92%)	58/813 (7.13%)	976/25202 (3.87%)	34/813 (4.18%)

Table 2: comparison of the frequency of a particular event (for example a conjunction), and the frequency of an earthquake that can be associated to the event during the period 1950/01/01-2018/12/31. The threshold used here to define a conjunction is $\theta_{thr} = 2^{\circ}$.